

# **Pharmacology and Toxicology of Alcohol: State of Knowledge and Implications for Motorcyclists**

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**National Transportation Safety Board**

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# **PHARMACOLOGY AND TOXICOLOGY OF ALCOHOL: State of Knowledge and Implications for Motorcyclists**

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# Today's Topics

- Why Alcohol?
- Scope of the problem
- Alcohol Pharmacology
- How the toxic effects of alcohol affect behavior related to motorcycle operation
- Relative Risk
- Special Problems: alcohol and head injury

# Why Alcohol?

~400,000 deaths related to alcoholism

~50,000 fatal MVAs

~16,000 alcohol-related fatal MVAs (.10%)

Up to 40% of all fatal MVAs involve alcohol  
(.01%)

Alcohol is the most studied drug on earth

Estimates approximate for comparative purposes

Data derived from Annual FARS Report

## Who Drinks and Drives?

### **Fatal Accidents Involving Alcohol**

- Highest risk are young men (~16-24)
- About 20% of alcohol sold in the US is consumed by teenagers!
- Men are 2x more likely than women
- Men drink about 2x as much as women

# What is Alcohol?

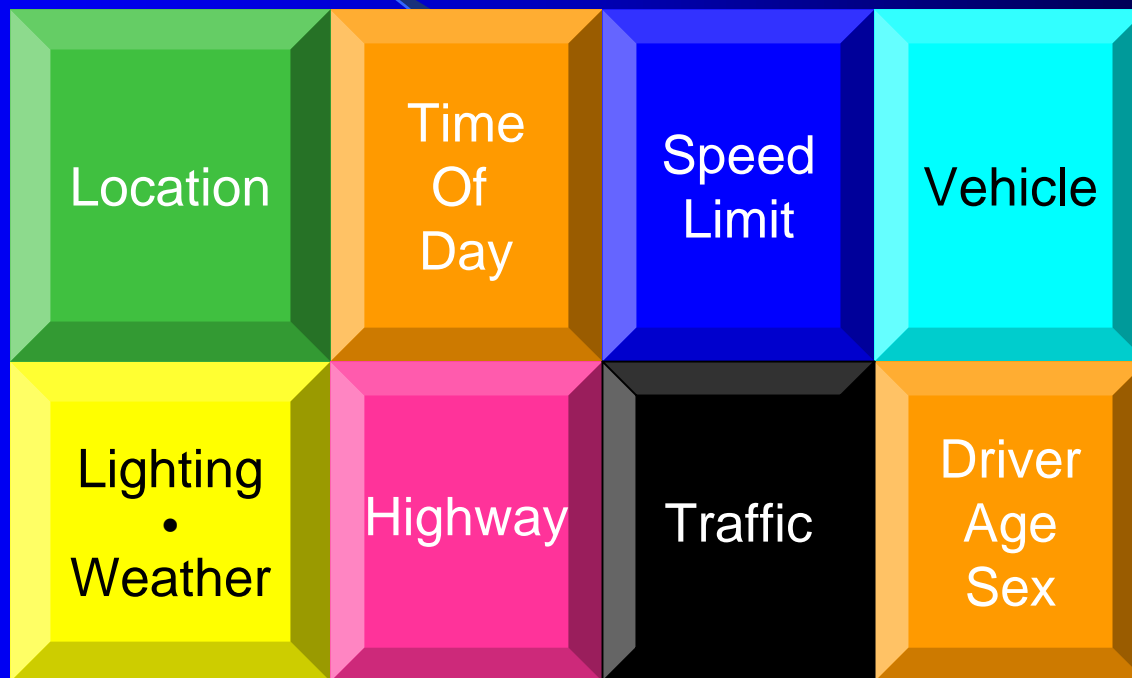


- Psychoactive drug
- CNS depressant
- Abused
- Addictive
- Popular

# Alcohol and Motor Vehicle Injuries

- Since the introduction of mechanized transportation, the number of vehicular injuries has increased as well as the number of accidental deaths due to alcohol.

# Factors Influencing Accident Risk



# Factors Influencing Accident Risk



**ALCOHOL  
INTOXICATION**

# Blood Alcohol and Behavior

## Scientific Issues in Alcohol-related Injuries

- Perception
- Vision (static, dynamic, field of vision, etc.)
- Sensory motor coordination (e.g., RT)
- Cognitive function (e.g., judgment)
- Attention (e.g., psychomotor multi-tasking)
- Relative risk
- Injury complications

# Blood Alcohol and Behavior

What does the research say about driving impairment and low BACs?

US Department of Commerce, National Technical Information Services,  
Springfield, VA 22161. DOT HS 807 280. Effects of Low Doses of Alcohol on  
Driving-related Skills: A Review of Evidence

# Blood Alcohol and Behavior

“... Impairment in all areas was significant by BACs of 0.05% and first appeared in many areas by 0.02% to 0.03%. Thus, scientific evidence suggests no lower limit can be placed on alcohol impairment of driving-related skills.”

US Department of Commerce, National Technical Information Services,  
Springfield, VA 22161. DOT HS 807 280. Effects of Low Doses of Alcohol on  
Driving-related Skills: A Review of Evidence

# **INFORMATION PROCESSING**

**Reaction time**

**Divided attention**

# Blood Alcohol and Behavior

## REACTION TIME (RT)

Reaction time is the difference in time from the initiation of one event, a target stimulus, to another event, usually a behavioral response such as pressing a keypad, brake pedal, etc.

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time.  
Forensic Examiner, Vol. 9 (11/12): 19-23 2000

# Blood Alcohol and Behavior

## REACTION TIME

Simple reaction time can be expressed by the formula  $RT = T1 - S1$ , where S1 is the moment in a timeline when a stimulus first appears and T1 is the length of time from S1 to the response.

$$RT = T1 - S1$$

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time.  
Forensic Examiner, Vol. 9 (11/12): 19-23 2000 (Review Article)

# Blood Alcohol and Behavior

## REACTION TIME

Changes in RT are often cited as an effect of alcohol. In many instances, RT is lengthened by alcohol – it takes longer to respond.

Not all studies show an effect of alcohol on RT.

The following slides illustrate the effects of BACs in the .08% range on RT.

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time.

Forensic Examiner, Vol. 9 (11/12): 19-23 2000 (Review Article)

# Blood Alcohol and Behavior

## REACTION TIME

Effect of Alcohol:

Speed of RT (detection, identification, processing and response) varies as a function of intoxication. In a meta-analysis, RT of subjects with BACs less than .10% were predicted by the following equations:

$$RT_{\text{alcohol}} = (1.12 RT_{\text{no alcohol}}) - 17.85$$

$$RT_{\text{alcohol}} = (1.22 RT_{\text{no alcohol}}) - 91.49$$

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time.

Forensic Examiner, Vol. 9 (11/12): 19-23 2000 (Review Article)

# Blood Alcohol and Behavior

## REACTION TIME

Effect of Alcohol:

$$RT_{\text{alcohol}} = (1.12 RT_{\text{no alcohol}}) - 17.85$$

$$\text{e.g., } (1500 \times 1.12) - 17.85 = 1662 \text{ ms}$$

$$\Delta = 166 \text{ ms or about } \sim 15 \text{ feet @ } 88 \text{ fsp}$$

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time. Forensic Examiner, Vol. 9(11/12): 19-23 2000

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# Blood Alcohol and Behavior

## REACTION TIME

Effect of Alcohol:

$$RT_{\text{alcohol}} = (1.22 RT_{\text{no alcohol}}) - 91.49$$

$$\text{e.g., } (1500 \times 1.22) - 91.49 = 1739$$

$$\Delta = 239 \text{ ms or } \sim 21 \text{ feet @ 88fps}$$

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time. Forensic Examiner, Vol. 9(11/12): 19-23 2000

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# Blood Alcohol and Behavior

## AGE AND REACTION TIME

Speed of information processing (detection, identification, processing and response) varies as a function of age. In a meta-analysis, RT of subjects over age 60 were significantly longer than younger subjects.

$$RT_{\text{OLD}} = 1.44 RT_{\text{YOUNG}}$$

@ 88 fps = 660ms = 58 feet

From: Brick, J. (1999) Biobehavioral Factors in Reaction Time. Forensic Examiner, Vol. 9 (11/12): 19-23 2000

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# Blood Alcohol and Behavior

## REACTION TIME

- Most studies show some effect of alcohol on reaction time. However, many studies show no little or no effect of low doses of alcohol on reaction time.
- About 1/3 of the studies show impairment of *simple reaction time* at BACs of .05% or less. More recent studies show more consistent effects, especially with complex RT.

US Department of Commerce, National Technical Information Services, Springfield, VA 22161. DOT HS 807 280. Effects of Low Doses of Alcohol on Driving-related Skills: A Review of Evidence

# Biobehavioral Effects of Alcohol

## DIVIDED ATTENTION

Time sharing or “multi-tasking” in which operator must attend to two or more events, responding to codes or stimuli that signify a required change in behavior.

- Driving is a divided attention task.
- Alcohol impairs divided attention at BACs as low as .02-.03%.

US Department of Commerce, National Technical Information Services, Springfield, VA 22161. DOT HS 807 280. Effects of Low Doses of Alcohol on Driving-related Skills: A Review of Evidence; Also see Brick, J. (2003) Facts on Driving While Impaired. Rutgers-State University of New Jersey

# Biobehavioral Effects of Alcohol

## DIVIDED ATTENTION

What are the elements of safe motorcycle operation?

Where and how is attention divided?

From: Brick, J. and Erickson, C. (1999) Drugs, The Brain and Behavior: The Pharmacology of Abuse and Dependence. Haworth Medical Press, pg. 69.

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# Biobehavioral Effects of Alcohol

## DIVIDED ATTENTION

- Motorcycle operators are required to:  
perceive and process information (speed, time/distance, detect and identify objects in roadway) and respond appropriately.

At the same time they must:

Steer, balance, adjust speed (brakes, throttle, shift), attend to traffic control devices, hazards, other vehicles, etc.

# Biobehavioral Effects of Alcohol

## DIVIDED ATTENTION

Target acquisition and RT... Bringing together reaction time, information processing and attention.

Ordinary events may take on a completely different time line when intoxicated, even at low levels.

*RT changes maybe insignificant compared to target acquisition time.*

# Biobehavioral Effects of Alcohol

Impairment in psychomotor skills and in particular, divided attention skills, increases the risk for a fatal crash...

# Blood Alcohol and Behavior

## The concept of “RELATIVE RISK.”

Relative risk is a statistical term that describes how, in comparison to sober drivers, intoxicated drivers are represented in fatal motor vehicle crashes.

Relative risk is useful in appreciating the consequences of alcohol intoxication, and in particular the significance of even low levels of alcohol in the blood.

## Review of some relevant BACs

0.0 -0.02%	Zero tolerance for underage drinkers
0.04%	Commercial Vehicle Operators (CDL)
0.08%	Definition of illegal intoxication
0.15-.20%	BAC for most DWI/DUI arrests in US

# Blood Alcohol and Behavior

## Low BACs Related to Accidents?

# Blood Alcohol and Behavior

<b>%BAC</b>	<b>RELATIVE RISK</b>	<b>BIOBEHAVIOR</b>
.03	NS	Impaired in lab tests
.06	2x	Impaired driving
.08	5x	Drunk by statute
.10	6x	Drunk by statute
.15	18x	Visible Intoxication
.18	30x	
.20	40x	
.30	>	Comatose
.35	>>	Surgical Anesthesia
.40	>>>	LD:50

Modified from Brick J. and Erickson, C. (1999), Drugs, The Brain and Behavior: The Pharmacology of Abuse and Dependence. Haworth Medical Press, pg 72;

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# Blood Alcohol and Behavior

%BAC	RELATIVE RISK (males 21-35)	BIOBEHAVIOR
.02-.049	~2.5-3x	Impaired on some lab tests. Increased risk for fatal crash
.05-.079	~6-8	Impaired driving. Note: .04% and higher defines intoxication in many European countries and for commercial operators in the US
.08-.099	~11-17	Drunk by statute

Modified from Brick J. (2003), Facts on Driving While Impaired. Rutgers University Center of Alcohol Studies. Available free at [www.rci.rutgers.edu/~cas2/](http://www.rci.rutgers.edu/~cas2/). Risk data from Zador et al. (2000)

# Intoxication and MVAs

Scientific literature is clear:

*“The FARS data also shows that nearly 40% of all fatal crashes involved a driver or non-occupant with a BAC of .01% or more...*

*...[an] analysis of the FARS data ... indicated that about 30% of the fatal crashes involved at least one driver or non-occupant with a BAC of .10%+”*

Source: NHTSA 2003

# Intoxication and MVAs

Scientific literature is clear:

- Some drivers are at increased risk for a fatal crash at BACs as low as .02%.
- Most drivers are impaired and at increased risk for a fatal crash at BACs above .05%.
- Almost every driver is impaired and at increased risk for a fatal crash at blood alcohol levels in the .08% range.

# Physiological Issues Related to Alcohol Impairment

Contrary to popular belief, intoxication does not reduce crash injury.

Rather, being intoxicated not only increases your relative risk for injury but exacerbates certain types of injuries.

# Physiological Issues Related to Alcohol Impairment

Occupant kinetics a factor in many injuries.

Injuries that apply to most motor vehicles may not apply to motorcyclists because of vehicle differences.

Seat belts and air bags offer protection to automobile drivers, but not motorcyclists.

Head injuries can be reduced by helmet use but are affected by alcohol.

# Physiological Issues Related to Alcohol Impairment

Intoxication and Injury Outcome

**FACT: About half of traumatic brain injured patients are intoxicated (.10% or more)**

# Physiological Issues Related to Alcohol Impairment

**FACT: Motorcyclists with head injuries are about 2 times more likely to have fatal head injuries if intoxicated (compared to sober controls)**

# Physiological Issues Related to Alcohol Impairment

**FACT: Intoxicated accident victims with CNS injuries are twice as likely to die sooner than anatomically matched controls.**

# Toxicology of Alcohol-Exacerbated Head Injury

- Inhibition of free radicals (dimethyl sulfoxide)
- Alcohol-induced cerebral edema (from lipid peroxidation)
- Hemorrhagic shock (produces acidosis with marked hypercarbia)
- Alcohol produces acidosis
- Acidosis may alter ventilatory response

# Summary

1. Alcohol is a drug that produces dose-dependent decreases in brain function and behavior
2. Effects relevant to motor vehicle operation in the lab at about 0.02%-0.03% and most drinking drivers are impaired (on the roadway) starting at ~ 0.05% BAC.

# Summary

3. Riding a motorcycle requires additional skills and challenges.
4. Cyclists in particular may be at higher relative risk for injury and higher risk for fatal head injuries, if intoxicated.

We are finished to a reasonable degree of scientific certainty.

Thank you, and Ride Safely!

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# For additional information

- Websites: [www.intoxikon.com](http://www.intoxikon.com)  
[www.nhtsa.gov](http://www.nhtsa.gov)
- Drugs, The Brain and Behavior: The Pharmacology of Abuse and Dependence (1999) (1 800 HAWORTH)
- Handbook of the Medical Consequences of Alcohol and Drug Abuse (2004) (1 800 HAWORTH)
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- Brick, J. (2003), Facts on Driving While Impaired. Rutgers University Center of Alcohol Studies, Piscataway, New Jersey